# Sources of Microbial Contamination In Urban Streams and Ocean Beaches Santa Barbara, California

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In cooperation with the City of Santa Barbara
with financial support from Heal the Ocean

# PROBLEM AND SCOPE

- Urban streams and ocean beaches in the Santa Barbara area have fecal indicator bacteria concentrations that exceed public health standards for recreational water.
- The source of the contamination and consequently potential mitigation strategies are not known.
- Scope of this study includes collection of hydrologic, geochemical, and microbiological data along Mission Creek and West Beach west of Mission Creek. Traditional hydrologic data used to target expensive analytical data such as:
  - Genetic and molecular microbiological analysis
  - Characterization of dissolved organic carbon composition
  - Tracers of wastewater origin

# Some of the many potential sources of fecal contamination to urban streams and beaches

Urban baseflow from storm drains

Resident animal populations (wild and domestic)


Problems compounded during stormflow—especially first flush


Large homeless population

Point sources from sewer pipes crossing streams and beach areas

Diffuse sources from leaking laterals and sewers

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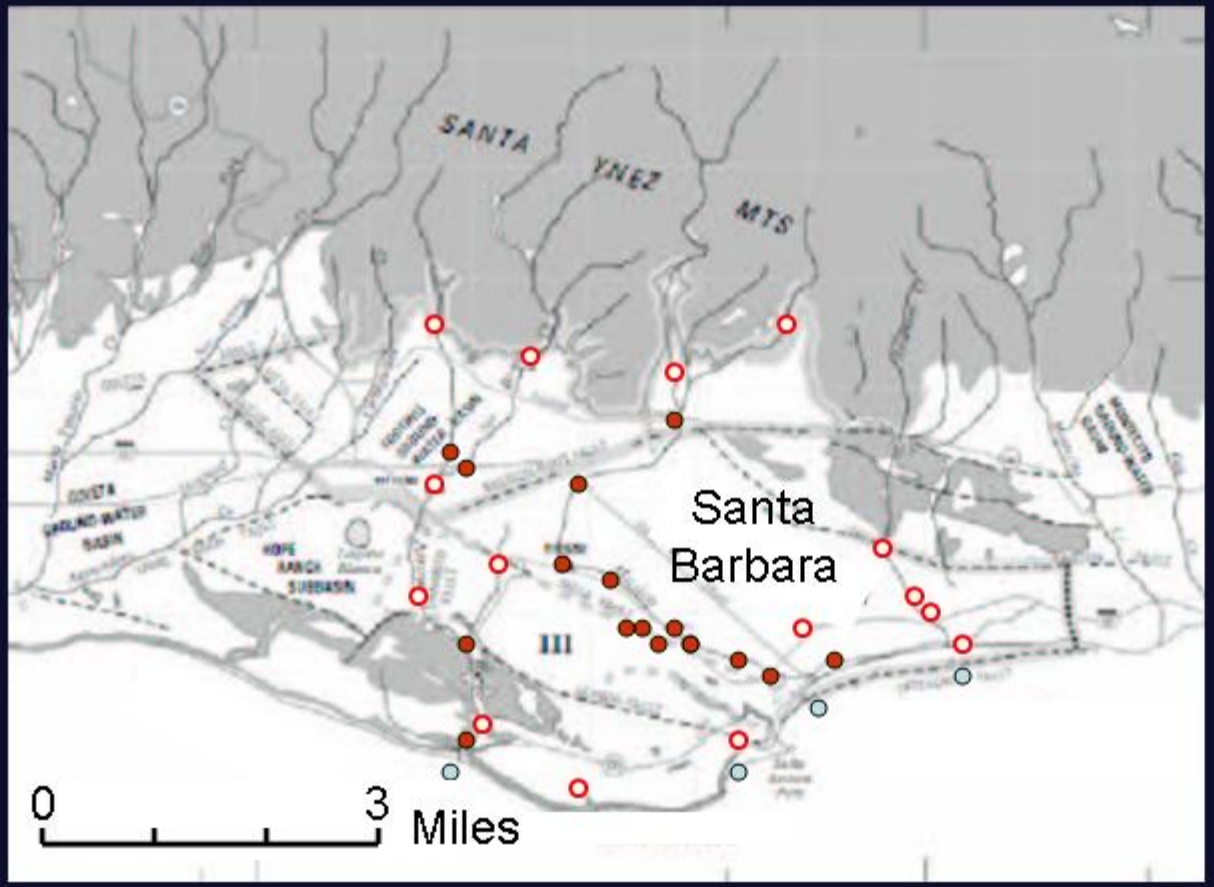
# LOCATION OF SURFACE WATER SAMPLE COLLECTION SITES




## EXPLANATION

Surface-water sites
- Historical
- Present study

Ocean beach sites
- Historical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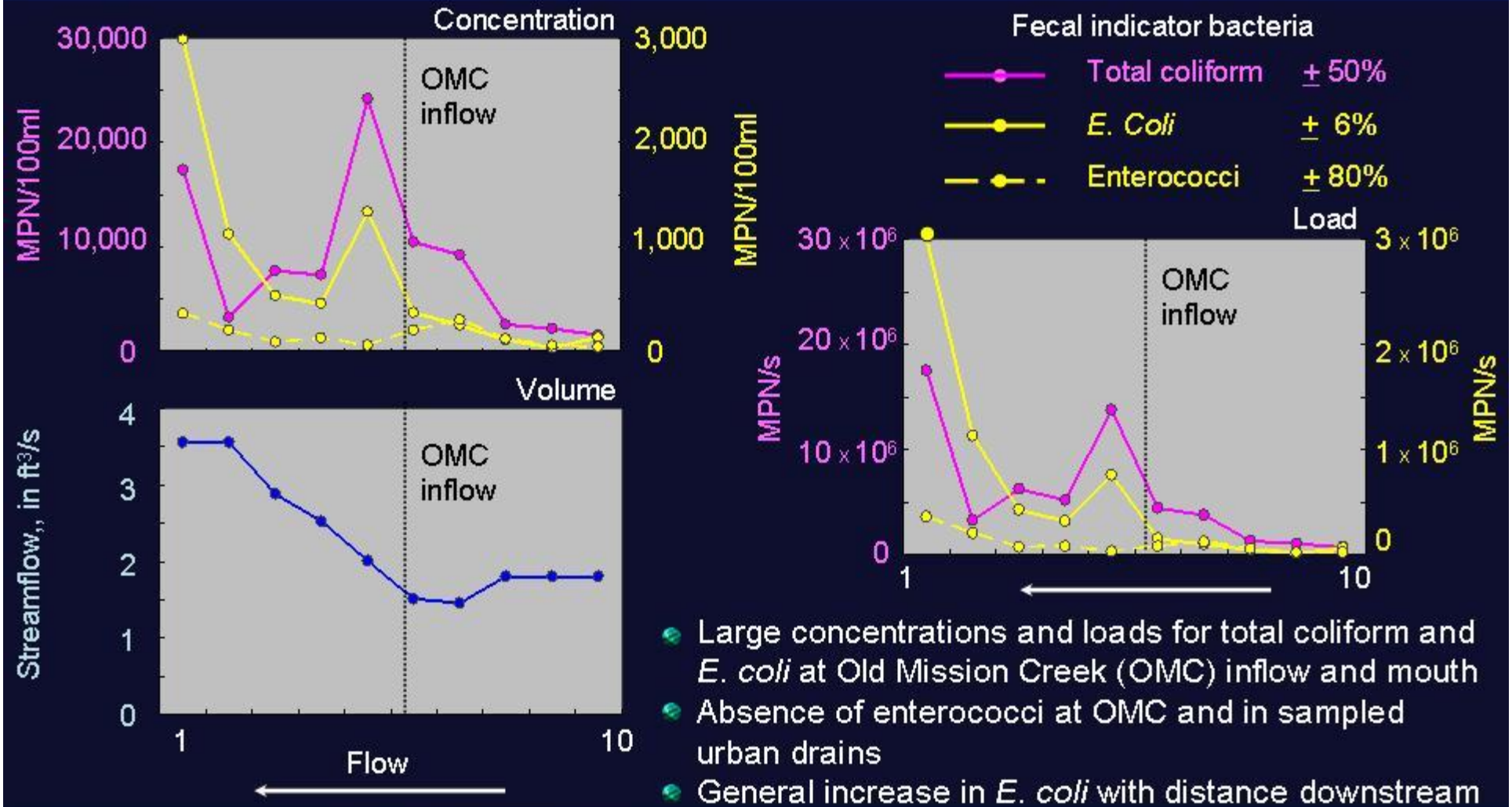
# Mission Creek streamflow and water-quality data, April 19-20, 2005




- Large concentrations and loads for total coliform and *E. coli* at Old Mission Creek (OMC) inflow and mouth
- Absence of enterococci at OMC and in sampled urban drains
- General increase in *E. coli* with distance downstream

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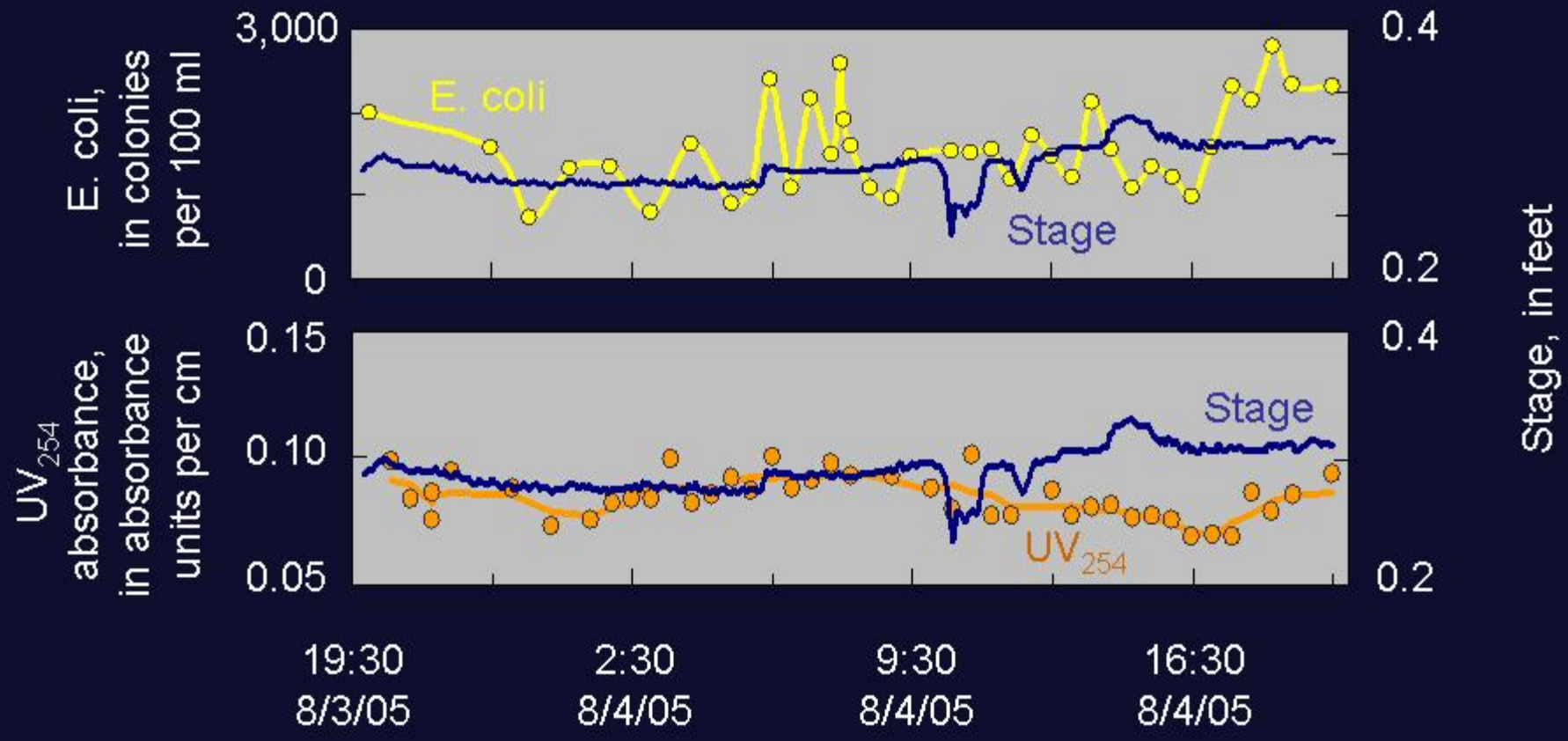
Concentration x Volume = Load

$MPN/L^3 \times L^3/t = MPN/t$

# Unsteady flow and bacteria concentrations

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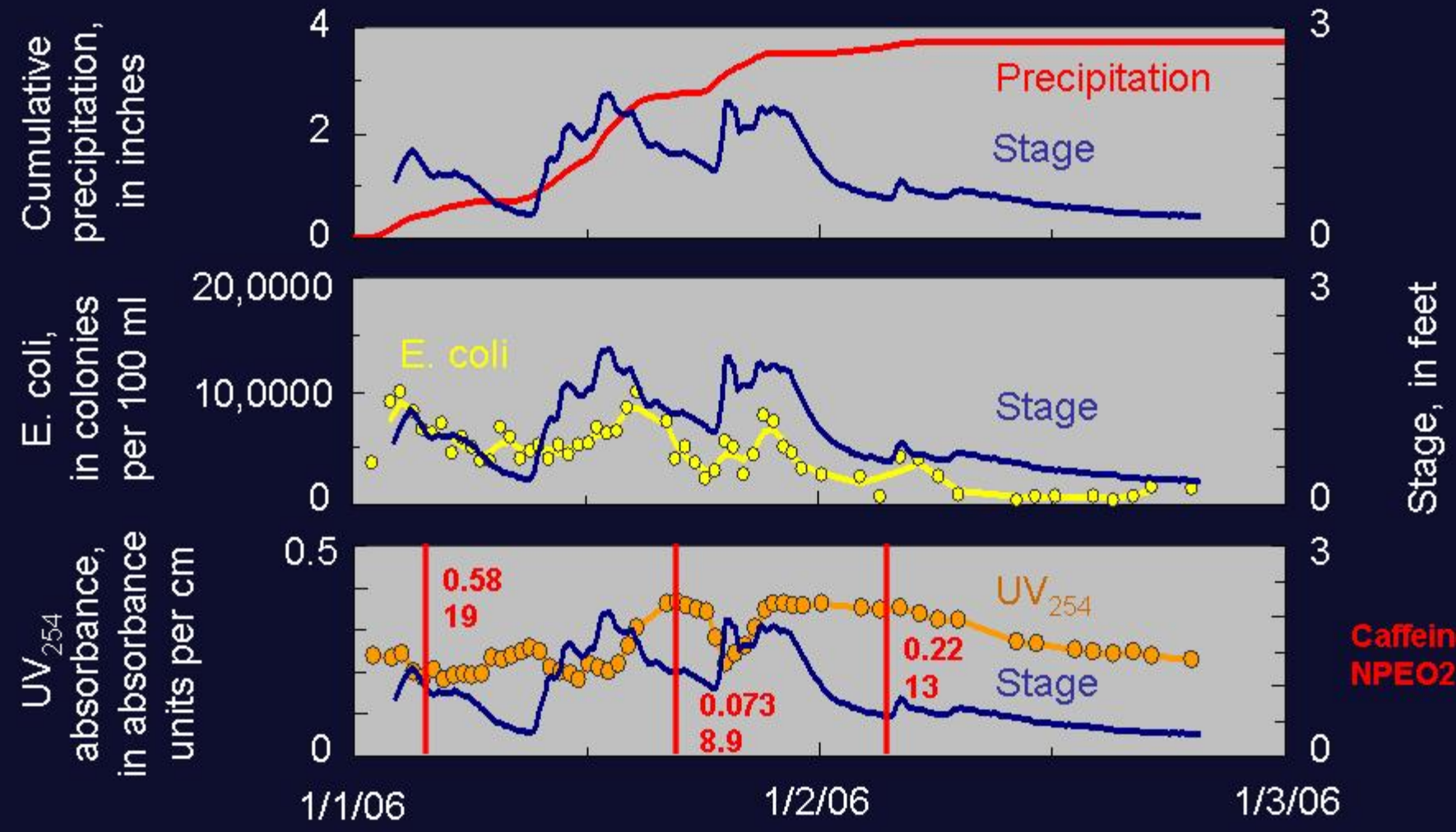
# Stormflow water quality, bacteria, and wastewater indicators

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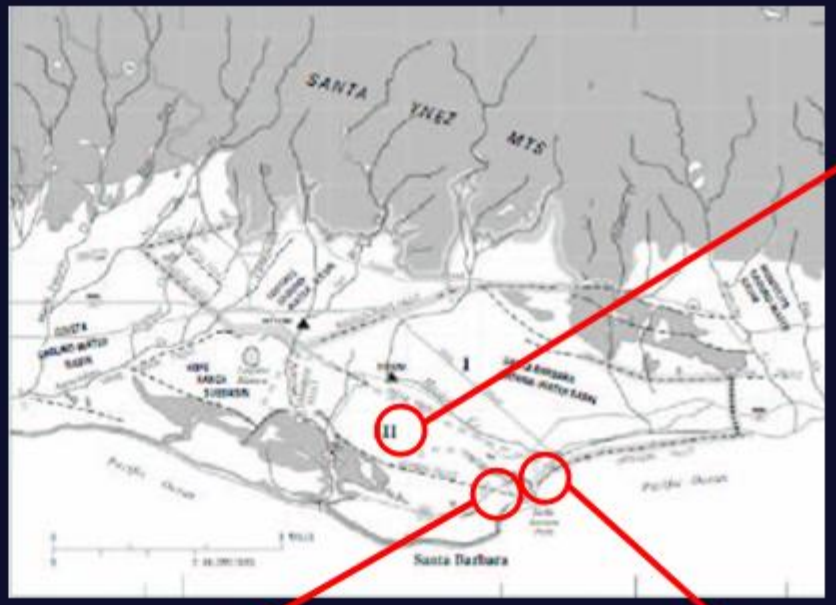
# Drilling and well installation

California District drill rig installing wells in Cabrillo Street

13 water-table wells installed to characterize different sources




3 wells in uplands

7 wells along in a cross section perpendicular to west beachfront

3 wells along east beachfront near lagoon

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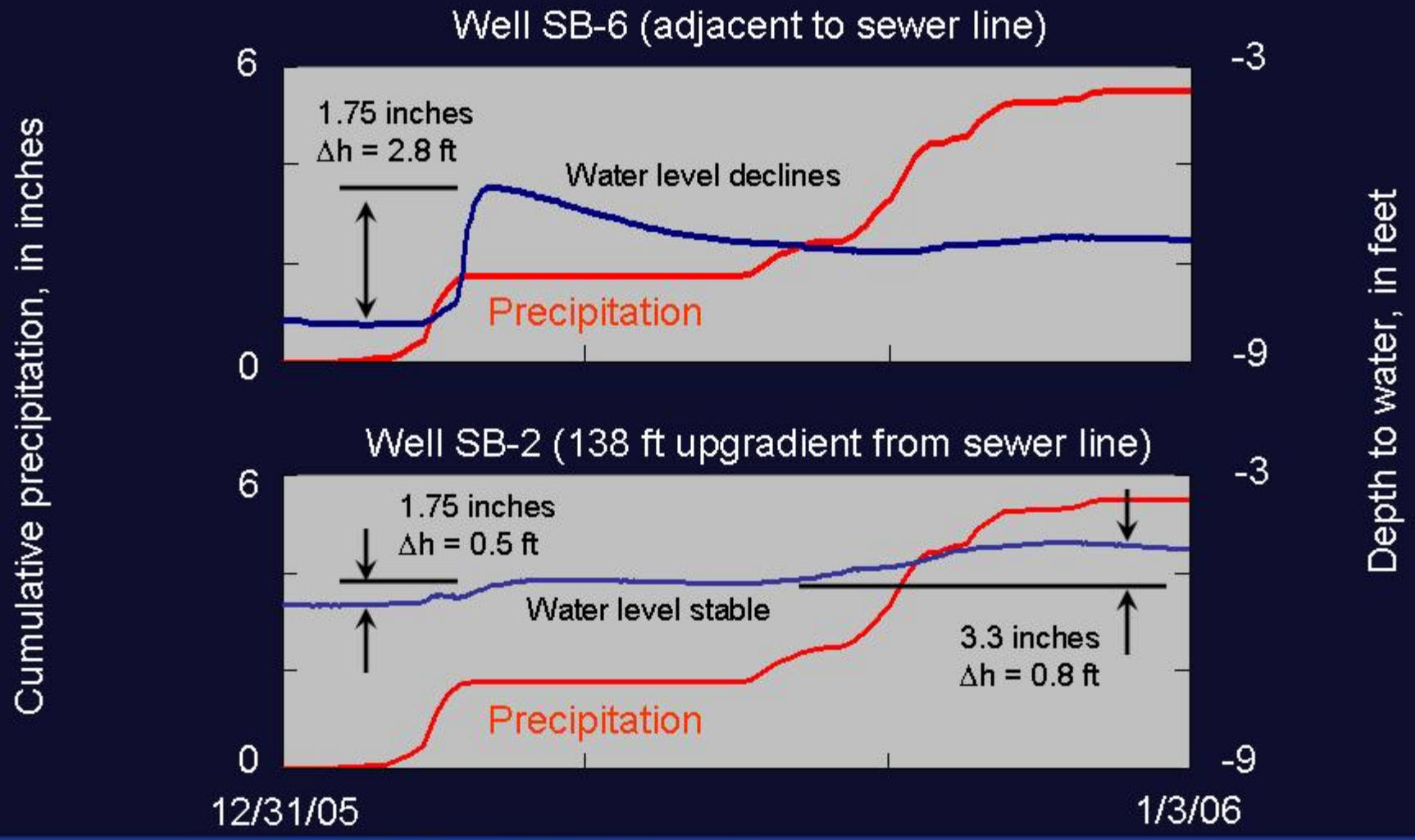
# Water-level response to precipitation

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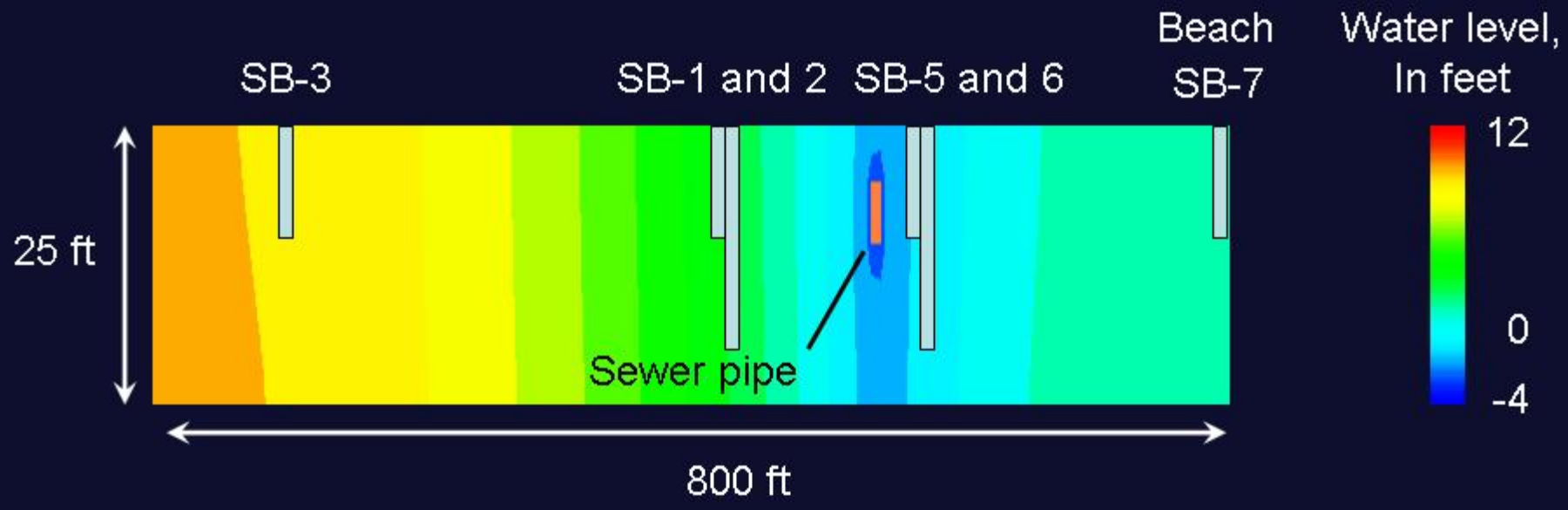
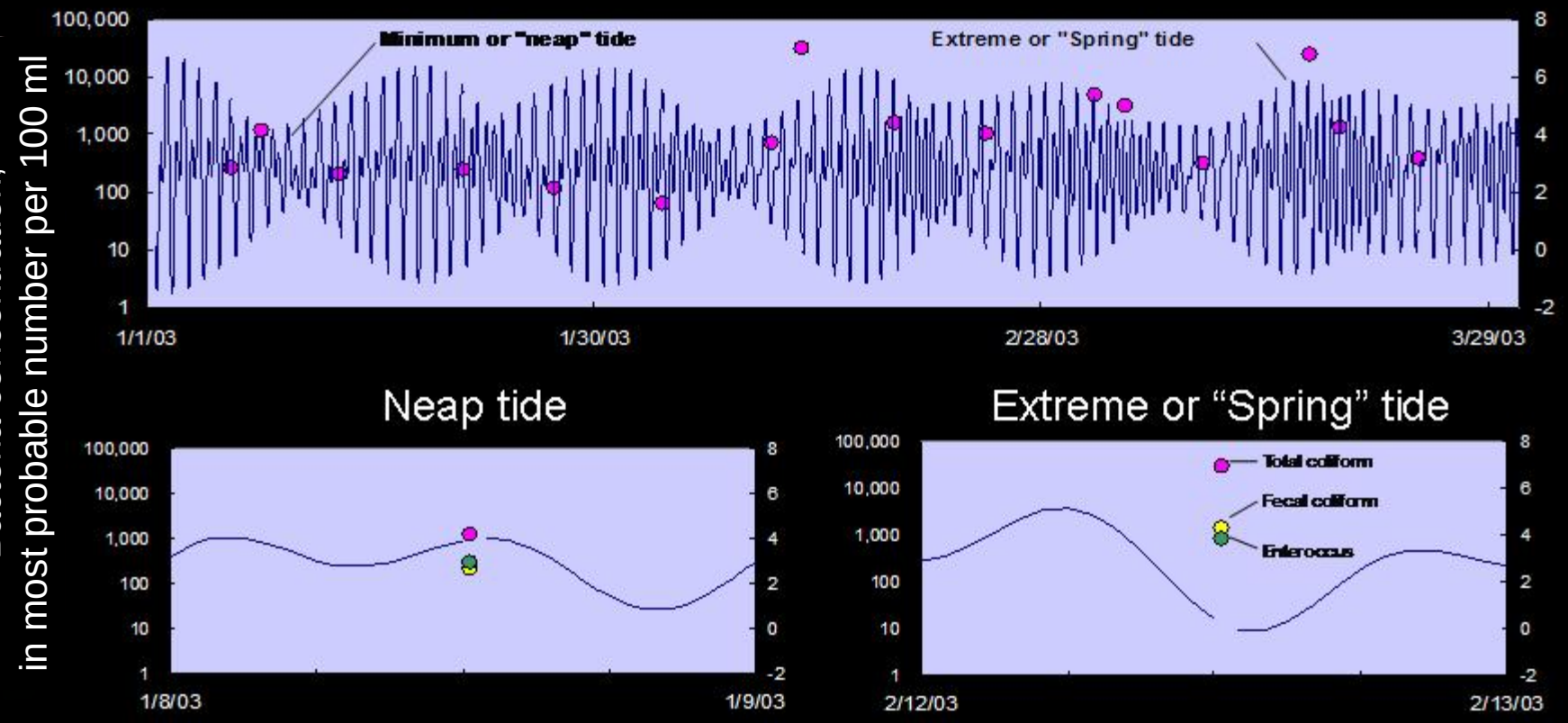
# Preliminary simulation of ground-water flow near sewer pipe




- Under most conditions groundwater flows into the sewer
- Simulate leakage from sewer pipe as a result of over pressure from:
  - Combined storm-sewer overflow (CSSO) associated with recharge
  - Large flush events not associated with recharge
- Does sewage ever escape the influence of the drain and reach the beach

# BACTERIAL CONCENTRATIONS AND TIDES

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# Measurement of ground-water discharge to the ocean

Direct measurement using seepage meter

Manganese coated fibers used to collect radium

Radon measurement continuously in the field

Equilibration of radon in ocean with air

Deploying direct-current resistivity array

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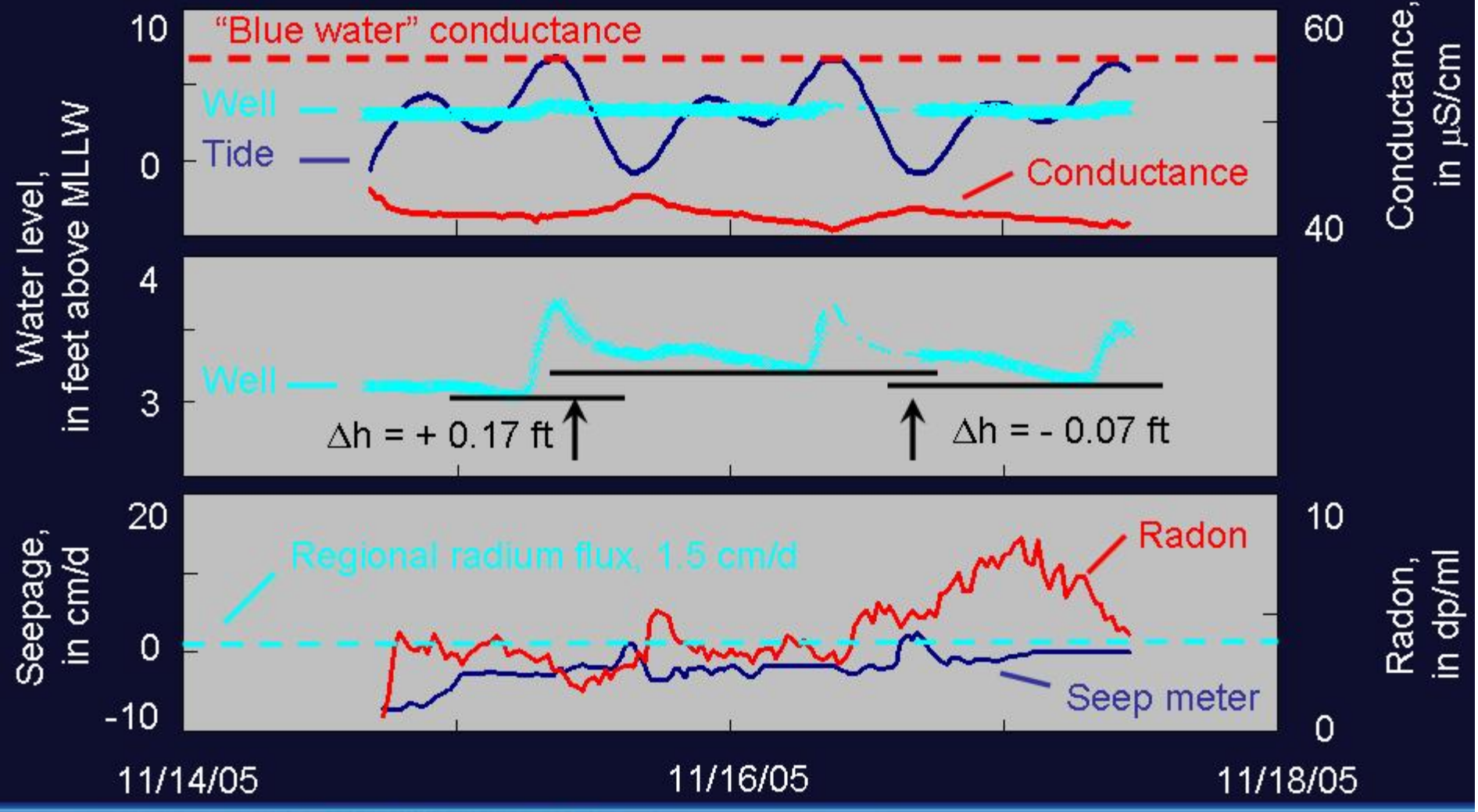
# Water Exchange at the Beach/Ocean Interface—Spring Tide

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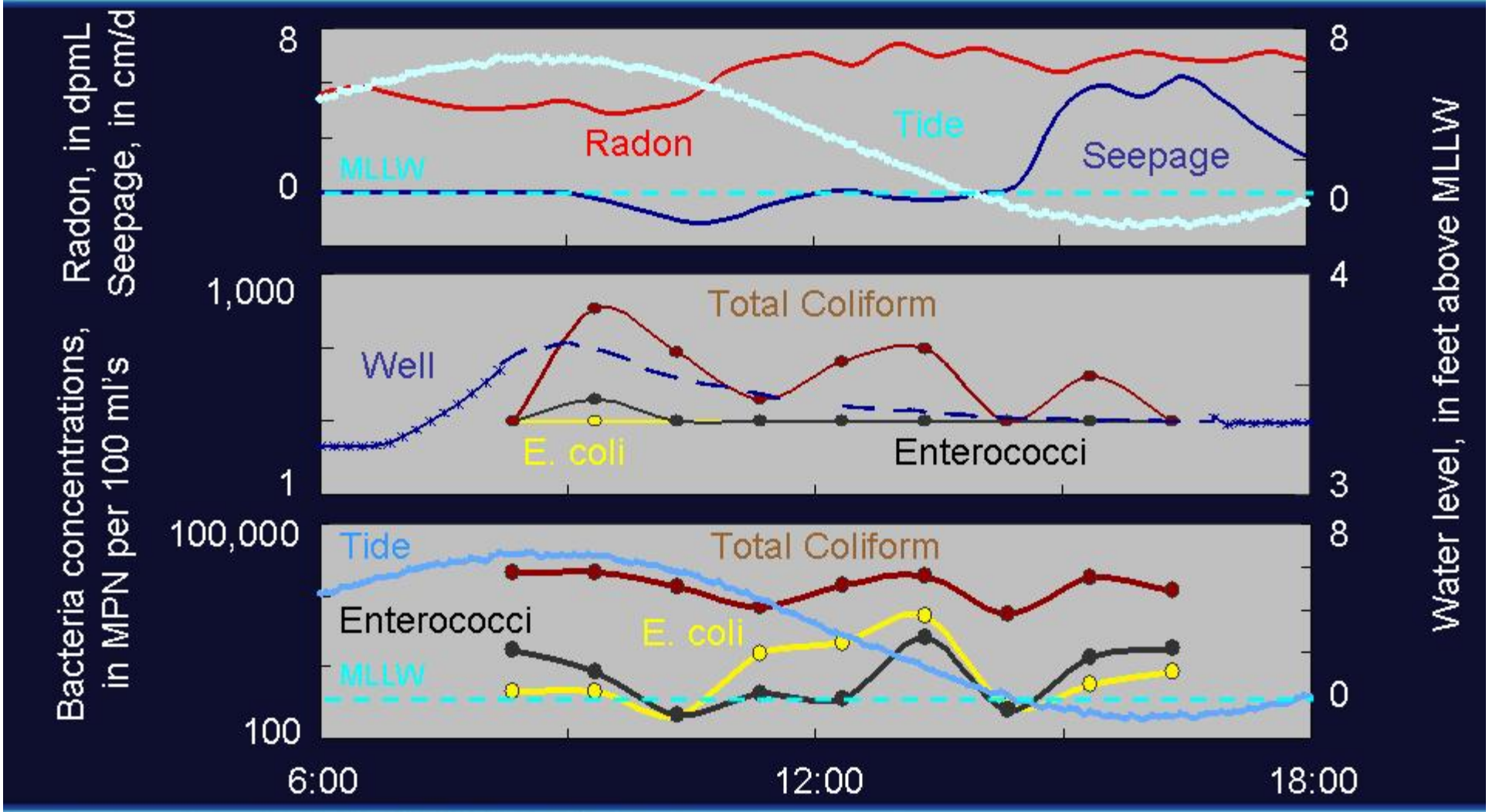
# Bacteria at the Beach/Ocean Interface—Spring Tide 11/16/05

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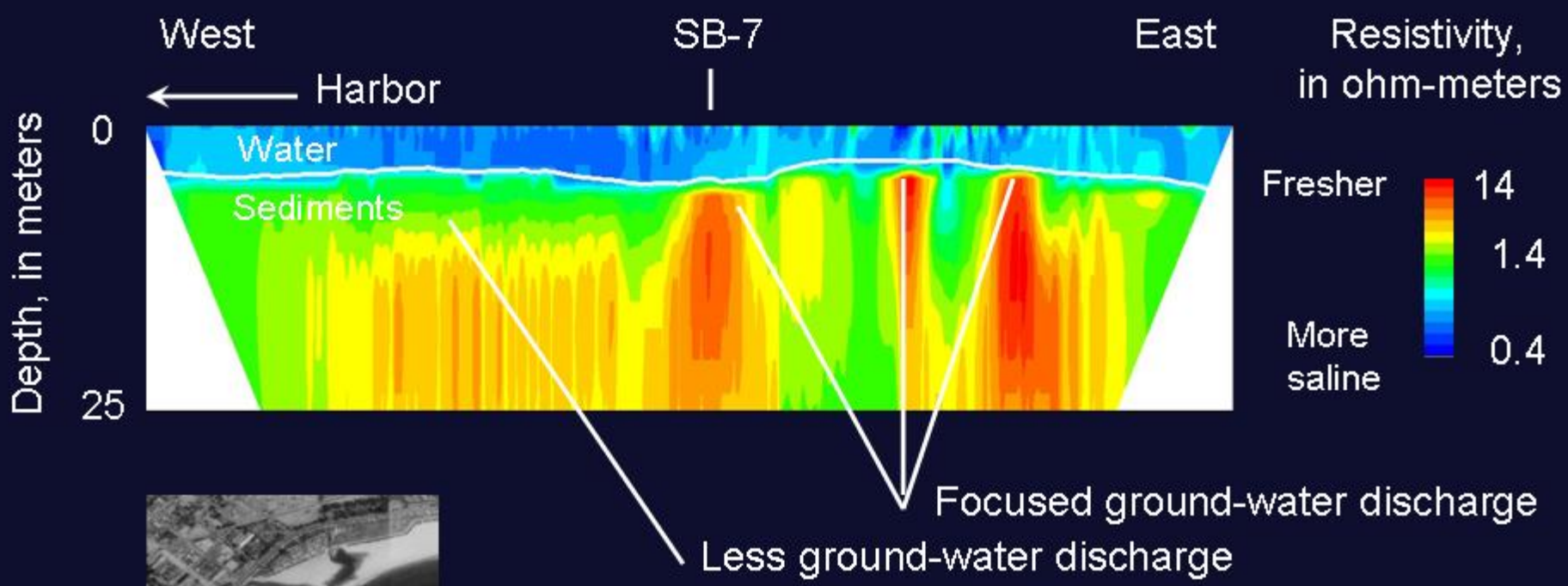
# Direct-current resistivity and ground-water discharge to ocean




- Multiple resistivity lines to assess spatial variations
- Repeat lines to assess variability during the tidal cycle
- On-shore stationary resistivity (May 2006)
  - greater spatial control
  - greater temporal control during tidal cycles

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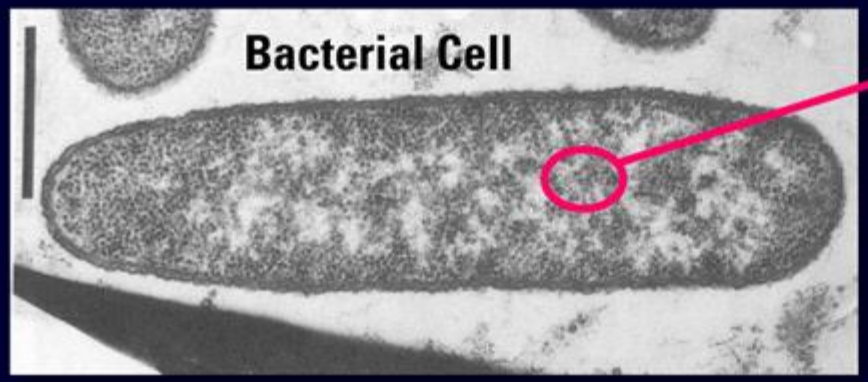
# DNA, molecular microbiology, optical property analyses, human bacteroides, human virus, and wastewater indicator data

- Expensive analytics
- Sample collection targeted on the basis of more traditional hydrologic and microbiological data
- Microbial Community Structure Analysis will be used to interpret DNA and molecular data within the context of more traditional hydrologic and microbiological data. The approach is less specific than "fingerprinting". However, interpretation is not dependent on a library of source samples, and is commonly better suited to "exonerate" potential sources rather than "implicate" sources

# Polymerase Chain Reaction (PCR) - a molecular copy machine




**Ribosomes**
Evolutionarily conserved, translate genetic information into proteins

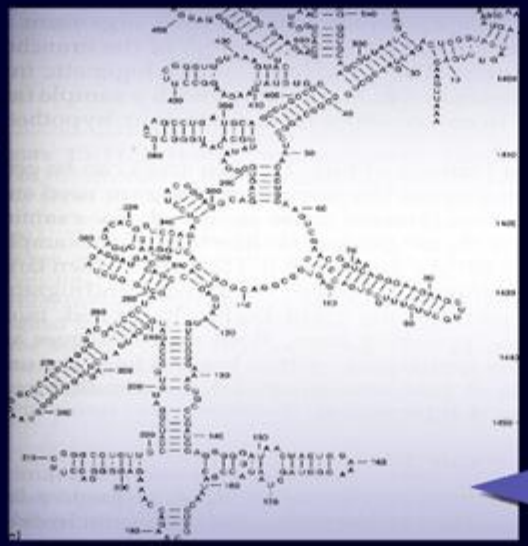
70s Ribosome

50s Subunit

30s Subunit

5s 16s 23s

Sequence of the 16S rRNA gene serves as a stable genetic "fingerprint" for each organism



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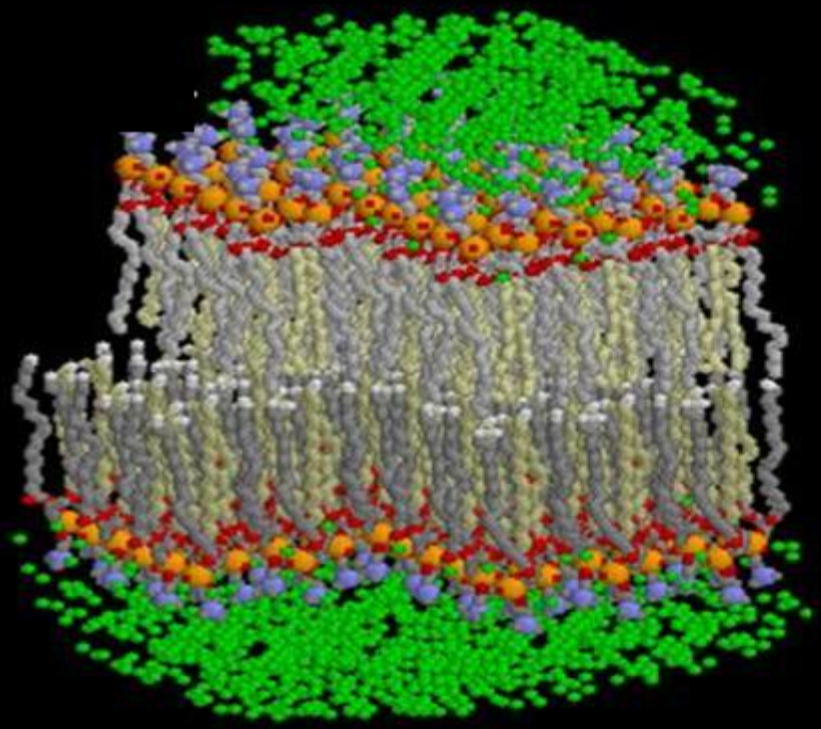
# Phospholipid Fatty Acids (PLFA)

## LIPID BI-LAYER IN A MICROBIAL CELL MEMBRANE



Carbon/Palmitic Oleic
Nitrogen Oxygen Phosphorus
Water Oxygens

H Heller, M Schaefer, K Schulten,
J Phys Chem 97:8343, 1993.
RasMol Image by E Martz

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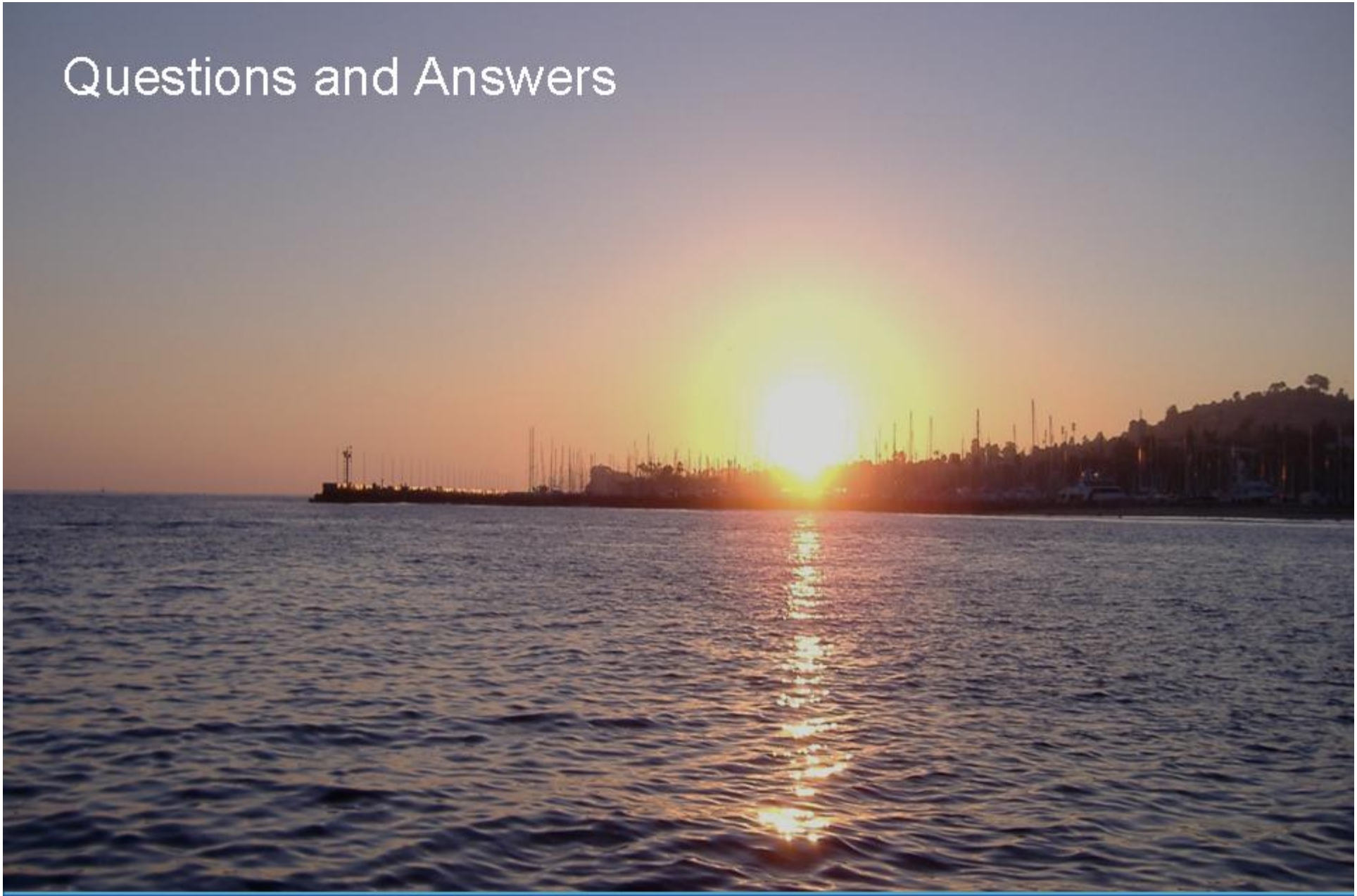
# Wastewater indicators (USGS NWQL)

- Caffeine
- Detergent metabolites
  - alkylphenol ethoxylates and nonlyphenol ethoxylates
- Flavors and fragrances,
  - camphor, skatol
- Anti-microbials
  - triclosan, d-limonene
- Flame retardents
- Sterols
  - coprostanol, cholesterol
- Additional characterization of sterols using two-dimensional gas chromatography (Robert Eganhouse, USGS, NRP)
  - 24-ethylcoprostanol, camperterol, 24-methylenecholesterol

# Preliminary conclusions — used to target expensive analytics during later phases of study

- Flow and bacteria concentrations are unsteady and point sources, such as urban drains, dominate streamflow bacteria concentrations and loads along downstream reaches during low flow
- Leaking sewer lines do not appear to contribute bacteria to streams during stormflow
- Ground-water discharge does not appear to contribute bacteria to beach areas during Spring tide
- Sewer pipes along beach area may leak when under pressure during peak flows and stormflows

# Questions and Answers



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